Data and Methodologies for Structural Life Evaluation of Small Airplanes

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The current small airplane "safe life" method (contained in FAA Report No. AFS-120-73-2, May 1973) is based on defining the appropriate usage category (e.g., single-engine general usage) and using the corresponding loads spectra for maneuver, gusts, taxi and landing. Stresses for a given loading are determined either by analysis or empirically derived stress equations from measured flight strain survey data. Airplane life is determined using Miner's cumulative damage rule with an appropriate scatter factor and S-N data.

The AFS-120 report needs to be updated for several reasons. First, the original report is based on 12,400 hours of VGH (velocity-load factor-altitude) data collected on 36 airplanes. VGH data collection continued until 1981, at which time 42,155 hours of data were accumulated on 105 airplanes. The Part 23 Airplane Fatigue Working Group was established in 1987, with the initial task of assisting the Small Airplane Directorate in developing updated fatigue substantiation guidance material. The Working Group recommended an updated loads spectra based on the complete VGH General Aviation Data Base. These loads spectra, including statistical analysis, are contained in FAA Report DOT/FAA/CT-91/20. Other recent reports (DOT/FAA/AR-00/11, DOT/FAA/AR-01/44) contain statistical loads spectra for commuters and small instructional airplanes. The first task of this project consists of reviewing these newly published usage data and comparing the loads spectra with the original AFS-120 data.

The second task of this project consists of developing guidance material to assist small airplane operators in determining a realistic loads spectra for fatigue evaluation. FAA guidance material, "Fatigue Evaluation of Empennage, Forward Wing, and Winglets/Tip Fins on Part 23 Airplanes," Report No. ACE-100-01, provides for two methods to develop a loads spectra: Method A: use statistical loads spectra based on usage and type, and Method B: use mission profiles and mixes to develop a loads spectra.

In addition to loads spectra data, the original AFS-120 contains S-N data (based on Royal Aeronautical Society Data Sheet E.02.01) for constant amplitude full-scale fatigue testing of complete wings and tailplanes constructed of aluminum alloys. The test articles were obtained from surplus 1940's wartime aircraft. These aircraft were not designed and manufactured with fatigue considerations. Hence, the S-N data is severe for aircraft that have been designed and manufactured to have a long service life. Industry Part 23 Airplane Fatigue Working Group members have provided data that indicate a Kt value as high as 5.6 for the AFS-120 S-N data. Comparisons with full-scale test data and MIL-HDBK-5 indicate that a Kt value of 4.0 provides a more realistic estimate of airplane life. The third task of this project is to determine S-N curve adjustments that can be applied to existing S-N data (MIL-HDBK-5, Damage Tolerance Design Handbook, Aerospace

Structural Metals Handbook, ESDU Data Items) and used with Miner's rule to predict full-scale structural life.